COMPOSITE DOWEL SYSTEM AND RELATED METHOD

Cross-Reference to Related Applications

[0001] This application claims priority to U.S. Provisional Application Serial No. 60/544,275, filed on February 12, 2004.

Background and Summary

[0002] The present invention relates to a composite dowel structure for a hollow support structure (e.g. a light pole), and to methods and structures used in creating such a composite dowel structure. The present invention also discloses related methods for preparing, repairing and/or reinforcing hollow support structures.

[0003] Hollow support structures such as light poles generally extend both in ground and above ground, and are often subject to deterioration (e.g. corrosion, wear) that can weaken the structures. For example, light poles may be constructed of steel, iron or fiberglass. With steel or iron poles, deterioration (e.g. corrosion) generally forms near the base of the pole, and may extend into the in ground portion of the pole. Unless the pole can be adequately repaired and reinforced, to compensate for the deterioration, the pole may require replacement. Structural deterioration of a hollow support such as a fiberglass pole can also require either adequate repair or reinforcement of the pole to compensate for the deterioration, or may require replacement of the pole.

[0004] Other types of load bearing hollow support structures can also suffer deterioration. For example, hollow support structures that are designed for use in an aqueous medium (e.g. a lake, stream, ocean or other body of water), may be subject to deterioration in a "splash zone" that is located across the portion of the structure that would normally be partially in the aqueous medium and partially out of the aqueous medium.

[0005] The present invention provides a method of creating a composite dowel to repair existing hollow support structures, e.g. hollow support structures made of steel, iron, or fiberglass, that have lost tensile, shear and bending strength due to corrosion or other types of structural deterioration.

[0006] Moreover, the present invention provides a hollow support structure with a composite dowel that is formed, in situ, in the support structure, and is designed to provide tensile, shear and bending strength to the support structure.

[0007] In addition, the present invention provides methods and structures that are useful in repairing a hollow support structure. For example, the method includes a new and useful technique for preparing the support structure for receiving an epoxy resin aggregate that produces the composite dowel structure.

[0008] A hollow support structure that has been repaired by a composite dowel structure according to the present invention is designed to provide high tensile, shear and bending strength structural reinforcement to the support structure (e.g. increase bending moment to withstand loads such as wind loads).

[0009] Additionally, the principles of the present invention can be used to form, in situ, a composite dowel structure that reinforces the hollow support structure, irrespective of whether the hollow support structure is in need of repair.

[0010] Still further, the present invention provides related techniques for reinforcing a hollow support structure, in situ.

[0011] Further aspects of the present invention will become apparent from the following detailed description and the accompanying drawings and exhibits.

Brief Description of the Drawings and Exhibit

[0012] Figure 1 is a schematic illustration of a hollow pole, before the pole is repaired and reinforced, according to the principles of the present invention;

[0013] Figure 2 is a schematic illustration of a hollow pole that has been repaired and reinforced with a composite dowel structure, according to the principles of the present invention;

[0014] Figure 2a is a schematic, three-dimensional illustration of a sleeve that is used in forming a composite dowel, in situ, according to a preferred embodiment of the present invention;

[0015] Figure 2b is a fragmentary illustration of a portion of a hollow pole that has a composite dowel structure formed, in situ, according to the principles of the present invention;

[0016] Figure 3a is a schematic illustration of certain steps in preparing a pole to be reinforced, according to the principles of the present invention;

[0017] Figure 3b is a schematic illustration of steps in completing reinforcement of the pole, according to the principles of the present invention;

[0018] Figure 4 is a fragmentary schematic illustration of a mouth formed in a fabric sleeve that has been installed in a pole, as part of the preparation of the pole structure, according to the principles of the present invention;

[0019] Figures 5a-h schematically illustrate certain steps in repairing and reinforcing a pole structure, according to the principles of the present invention; and

[0020] Figure 6 is a schematic illustration of an alternative way of repairing and reinforcing a pole structure, according to the principles of the present invention.

[0021] Exhibits 1a-1h are illustrations of the steps illustrated in Figures 5a-h.

[0022] Exhibit 2a is an illustration of the sleeve of Figure 2a.

Detailed Description

[0023] As described above, the present invention relates to a composite dowel structure, and to related techniques, for preparing, repairing and/or reinforcing a hollow support structure such as a light pole. The principles of the invention are particularly useful in repairing and reinforcing a deteriorated portion of a light pole, and are described below in connection with a deteriorated portion of a light pole made of steel or iron. However, from that description, the manner in which the principles of the present invention can be used to reinforce various other types of hollow support structures will be apparent to those in the art.

[0024] As illustrated in Figures 1 and 2, a light pole 100 comprises a hollow body 102 that is made of iron or steel, and has an above ground portion 104 and an in ground portion 106. The pole 100 has a deteriorated portion 108 that is disposed at ground level 110, and extends partly into the in ground portion 106. The deteriorated portion 108 has been caused by corrosion or other environmental conditions. According to the present invention, the pole 100 is repaired and reinforced in a manner that a composite dowel structure 112 is formed, in situ, in the pole, and repairs and strengthens the pole. In the embodiment of Figure 2, the composite dowel structure 112 comprises a high tensile strength fabric sleeve 120 that is filled and saturated with an epoxy resin aggregate material 116.

[0025] As illustrated in Figures 1 and 2, the pole 100 has an access opening 118 that is located in the above ground portion 104 of the pole. The access opening 118, which may have a removable cover (not shown), that normally enables technicians to access the electronic components (e.g. wires, cables) inside the pole. According to the present invention, the access opening 118 is useful in preparing the pole for the formation of a composite dowel structure, in situ, in the pole, and in forming the composite dowel structure, in situ, in the pole, as described in more detail below. If no access opening exists one must be created.

[0026] Initially, the pole 100 is inspected, and the deteriorated portion 108 identified. In applicant's experience, the deteriorated portion 108 may result in an

opening 108a (Figure 5a, Exhibit 1a) that extends slightly above ground level 110 and also extends into the in ground portion 106. During the inspection of the pole, the depth D of the deteriorated portion 108 (i.e. the vertical distance over which the deteriorated portion extends) is preferably determined.

[0027] It is preferable to wrap the exterior of the pole, at least over the depth D of the deteriorated portion 108. A fiberglass or carbon fabric (sometimes referred to as FibreCast) can be wrapped about the pole and adhered to the pole by an epoxy resin. In Figure 2, the wrapping is schematically shown at 119, and its purpose is to contain the dowel materials in the pole, during installation. Suitable wrapping materials can be obtained from HJ3 Composite Technologies, LLC (Tucson, Arizona), but there are various tapes and wrappings on the market that would be suitable as a wrapping for the pole, to contain the dowel materials in the pole during installation. It is also preferred to prepare the outer surface of the pole (e.g. brush the outer surface with a wire brush, to remove loose paint and debris, and wipe the surface with a rag saturated with acetone), before wrapping the tape, to eliminate significant areas of corrosion that could interfere with the effective wrapping of tape about the pole (see. e.g. Figure 5b and Exhibit 1b). The wrapping 119 also protects against water and oxygen, the main ingredients for corrosion, while also providing protection from damage from landscaping tools (e.g. weed whackers) that may be used about the pole. The tape wrapping is intended to seal voids so that epoxy resin aggregate does not leak out of the pole during the formation of the composite dowel. While it is preferred to wrap the tape about the deteriorated portion 108, as part of the preparation of the pole, it is also recognized that under certain circumstances (e.g. if the corrosion has not created a hole extending completely through the pole), wrapping the tape about the deteriorated portion of the pole can also be performed just before the epoxy resin aggregate is poured into the pole. Figures 3a and 3b illustrate, in dashed lines, points in the process at which the wrapping could be applied.

[0028] It is also desirable, during the inspection of the pole, to determine if there is a predetermined amount of "good pole material" below the access opening 118. With a steel pole, for example, it is preferable to determine that there is at least 6" of continuous good steel ("good steel" meaning not heavily corroded) between the ground

110 and the bottom of the access opening 118. This can be subjective, but a gauge reading of the thickness of existing steel in this area will show the degradation of the steel. If there is less then 15% steel loss, then the steel is considered "good steel". If it is determined that there is not at least 6" of continuous good steel between the ground and the bottom of the access opening 118, then a new access opening must be cut above the existing access opening (and the cover of the existing access opening should then remain on). Installation crews can use a grinder to cut a new access hole into the steel pole. It is also considered desirable to insulate the wires on the inside of the pole by placing a fire resistant cloth up through the existing access opening to the point where the new access opening will be cut to minimize damage to existing wires.

[0029] In preparing the pole for the formation of a composite dowel structure, in situ, a tape measure can be placed into the access opening 118 of the pole and pushed to the depth of the pole to determine the distance below ground that the pole is buried. Once that distance is determined, a fabric sleeve 120 is formed and configured to be located inside the pole. The fabric sleeve preferably has two sleeve parts; an outer sleeve 122 part formed primarily of fiberglass, and an inner sleeve part 124 formed primarily of carbon (see e.g. Figures 2a, 2b). Each sleeve part is preferably formed with biaxial fibers (preferable at 45 degree angles of fiber orientation in a cris-cross pattern). The carbon and glass sleeves are cut to appropriate equal lengths, such that the length of the sleeve 120 is preferably the distance measured from the bottom of the pole to the bottom of the access opening 118 (plus about 12 to 18 inches for slack).

[0030] An important step in preparing the pole for the formation, in situ, of a composite dowel structure, is the step of placing the sleeve 120 in the pole. Initially, the carbon sleeve part 124 is placed inside the fiberglass sleeve part 122, so that when the sleeve 120 is inserted in the pole, the fiberglass sleeve part 122 contacts the interior steel wall 121 of the pole (see Figure 2b). This will insulate the more durable carbon sleeve part 124 from the steel pole, avoiding galvanic corrosion (due to dissimilar materials). The lower end of the sleeve 120 is tied off (e.g. by a zip tie, see Figure 5c and Exhibit 1c), and the upper end of the sleeve 120 has an opening 126 that is used to form a mouth surrounding the access opening, whose purpose is described below. The sleeve 120 is placed over a rod 127, e.g. a flexible poly vinyl chloride (pvc) rod 127

(Figures 5d, Exhibit 1d), which is preferably 5 feet of ½ inch flexible pvc material, and the rod with the combined carbon/glass sleeve is inserted into the pole through the mouth 126 (Figure 5d) and the access opening 118 until the rod reaches a predetermined depth, which can be as much as the bottom of the in ground part of the pole. The rod 127 acts as a plunger, to push the sleeve 120 to a predetermined depth in the pole, which can be the bottom of the in ground part of the pole. Then, the rod 127 is pulled out of the sleeve, leaving the combined carbon/glass sleeve inside the pole, and with the opening 126 of the sleeve located at about the access opening 118 in the pole (Figure 4). The border of the opening is rolled back about the outside of the access opening 118, so that the opening 126 forms a mouth at the access opening of the pole. The mouth 126 enables epoxy resin aggregate to be poured into the sleeve and the hollow pole. During this preparation stage, it is desirable to push any wires or cables inside the pole against the back of the pole (away from the access opening).

[0031] The epoxy resin aggregate is a high tensile strength material, and is preferably formed in the following way. The epoxy resin aggregate preferably comprises the following materials: (a) Sand; (b) Gravel: e.g. 3/8" Granite; (c) Saturating Resin (Epoxy), which can be e.g. HJ_3 SR-400A brand saturating resin (HJ_3 Composite Technologies, LLC, Tucson, AZ), or another commercially available saturating resin that is a true epoxy; (d) an epoxy hardener, e.g. HJ_3 SR-400B brand epoxy hardener (HJ_3 Composite Technologies, LLC, Tucson, AZ), or other commercially available epoxy hardener. The proportions of the foregoing materials of the aggregate are preferably: 24% epoxy resin, 12% epoxy hardener, 33% sand, and 33% granite (3/8" diameter).

[0032] The foregoing materials are placed in a 5 gallon bucket, and a paddle on a low speed drill (400-600 rpm) is used to mix the aggregate for 3 minutes at a slow speed to minimize the creation of air bubbles. After the epoxy components are mixed (for about 3 minutes), the sand and gravel are added. Mixing is then continued for a minimum of 2 additional minutes, or until the aggregate is completely blended. The consistency of the aggregate should be that of syrup. The pot life of the foregoing preferred aggregate is 30 minutes to 1 hour depending on the outside temperature. Epoxies develop heat during mixing and curing. The temperature rise will depend on

mass as well as formulation of the epoxy. To keep temperature to a minimum, it is preferred to maintain a high surface area to volume during mixing. Moreover, it is preferred to keep each mix volume to three gallons or less.

[0033] The epoxy resin aggregate is then poured into the mouth 126 of the combined carbon/glass sleeve. It may be desirable to wrap the pole prior to pouring the epoxy resin aggregate (see, e.g. Figure 3b, Figure 5e and Exhibit 1e). A trough 129 (Figure 5f, Exhibit 1f), formed preferably of a metal base with a coating or cover (e.g. of Mylar film) enables the epoxy resin aggregate to be efficiently poured through the mouth 126 and into the sleeve and the hollow pole, until the aggregate reaches 2 inches below the bottom of the access opening 118 (Figure 5g, Exhibit 1g). Then, the mouth 126 of the combined carbon/glass sleeve is placed into the pole and pressed down so that the remaining epoxy resin aggregate material is below the bottom of the access opening 118.

[0034] In this state, the carbon/glass sleeve 120, which has high tensile strength, is located inside the pole, with the glass sleeve part 122 against the interior wall 121 of the pole and separating the carbon sleeve part 124 from the inside of the pole (Figure 2b), and the sleeve extends a depth that at least includes the depth of the deteriorated portion 108. The high strength epoxy resin aggregate 116 substantially fills the pole, and saturates the carbon/glass sleeve 120 (Figure 2b) at least to a depth that encompasses the deteriorated portion 108.

[0035] If it is desired to wrap the tape about the pole after the epoxy resin aggregate has been poured into the pole, the tape is wrapped about the deteriorated portion at this point (Figure 3b). The epoxy resin aggregate is then allowed to cure, in situ, to complete the composite dowel structure. With such a structure, the high tensile strength sleeve 120 is located over the depth of the deteriorated portion of the pole, is saturated with epoxy resin aggregate, and forms a high tensile strength dowel structure that repairs and reinforces the pole, particularly over the depth of the deteriorated portion.

[0036] Once the composite dowel structure is formed, the pole may be finished by replacing the access opening cover, and painting the outside of the pole (Figure 5h, Exhibit 1h).

[0037] The foregoing structure and method relates to forming a composite dowel structure, in situ, completely inside the pole. It is also possible to repair and/or reinforce a hollow structure such as a pole by a method that at least partially includes providing reinforcement on the outside of the pole. Such a technique can be appreciated by reference to Figure 6. In Figure 6, a pole 140 has a deteriorated portion 142 that may be similar to the deteriorated portion in the prior embodiment. Once the depth D of the deteriorated portion of the pole is identified, a high tensile strength fabric 144 is saturated with a high strength epoxy material, and wrapped about the pole such that the high tensile strength fabric extends at least over the depth of the deteriorated portion 142 of the pole that is being reinforced, and the high strength epoxy material is then allowed to cure, in situ. The fabric 144 preferably comprises a fiberglass fabric part 146 disposed against the pole 140, and a carbon fabric part 148 disposed against the fiberglass part 146.

[0038] With this technique, the wrapping on the exterior of the pole may be adequate to repair and reinforce the deteriorated portion of the pole. However, it is further contemplated that a composite dowel structure can also be formed by pouring an epoxy resin aggregate 150 into the hollow pole structure, to at least a depth such that the epoxy resin aggregate fills the hollow pole in the area that encompasses the deteriorated portion, and allowing the epoxy resin aggregate to cure, in situ. The epoxy resin aggregate may be poured to the full depth of the pole, or structure such as rocks 152 (or other filler), and a bottom sheet 154 may be inserted into the hollow pole, to effectively control the depth to which the epoxy resin aggregate extends. With this technique, no sleeve would be provided inside the pole.

[0039] From the foregoing description, it should be clear that while the present invention is particularly useful in repairing and reinforcing a hollow structure such as a pole, the principles of the invention can be used to reinforce a hollow support structure, irrespective of whether the hollow support structure has a deteriorated portion, or

requires repair. Moreover, the principles of the present invention can be use to repair and/or reinforce various hollow support structures, (e.g. truss or lattice types of structures in which hollow poles or other types of hollow structures function as supports, hollow support structures for off shore platforms, etc.).

[0040] Additionally, while a fabric sleeve and high tensile strength epoxy aggregate are preferred materials to form the composite dowel structure, in situ, the principles of the present invention can be used to form other types of composite dowel structure, in situ, in a hollow support structure. For example, rather than a fabric sleeve, a high tensile strength material such as rebar can be inserted into the hollow pole, to a depth that extends over the depth of the deteriorated portion, and a cementicious aggregate material (i.e. an aggregate that is concrete based) can be poured into the hollow pole, to a depth that incorporates the rebar over the depth of the deteriorated portion of the pole, to form a composite dowel, in situ, in the pole.

[0041] Accordingly, the present invention provides new and useful structures, and related methods for repairing and/or reinforcing hollow support structures such as light poles.

[0042] In addition, the principles of the present invention can also be used to repair and/or reinforce various other types of hollow support structures. For example, hollow support structures that are used in aqueous medium (e.g. lakes, streams, oceans, and other bodies of water) may be subject to deterioration in a splash zone (e.g. particularly the portions of the hollow structures that may be partly above and partially below the aqueous medium, depending on the state of the aqueous medium). Thus, whereas the disclosed embodiment shows a light pole above and below a ground line 110, if a hollow support structure was used in a body of water, the water line (which could vary over the depth of the hollow support, depending on, e.g., the tides or the weather) would be conceptually similar to the ground line (is often referred to as a "splash zone"), and the portions of the support structure that are above and below the medium (i.e. above and below the "splash zone") could be subject to deterioration in much the same way as the portions of an in ground pole that are above and below the ground line.

Such hollow support structures can be repaired and/or reinforced in similar ways to the light poles described above.

[0043] Moreover, the principles of the present invention can be used to repair and/or reinforce virtually any hollow load bearing support structure, by forming a composite dowel structure in the hollow support structure, in the manner described above. The principles of the invention can be used to form a composite dowel structure in a predetermined portion of a hollow structure, and that predetermined portion can be all or most of the hollow structure, depending on the particular need for forming the composite dowel structure.

[0044] With the foregoing disclosure in mind, the manner in which the principles of the present invention can be used in connection with the preparation, repair and/or reinforcement of various types of hollow support structures will be apparent to those in the art.